Space Weather Technical Forecast

Issued on Monday, 21 March 2022 at 12:39 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Slight solar radiation enhancement observed from far-sided event, else no significant activity.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Low over the past 24 hours, with a solitary C1.3 X-ray flare observed at 20/1810UTC from a possible new sunspot region on the southeastern limb. All other activity was otherwise below C-class, with only two numbered and relatively unchanging sunspot regions on the disc: AR2972, a Bxi/Beta; and AR2973, a Bxo/Beta.

A Type-II radio burst with an estimated speed of 394km/s was observed with a peak of 21/0549UTC. This was apparently tied to an energetic far-sided Coronal Mass Ejection (CME) seen heading southwest on UTC morning coronagraph imagery, with the source not visible from Earth. This appears to have emerged diametrically opposite STEREO A's viewpoint, i.e. from about 120 West. No Earth-directed CMEs were observed in the period.

Solar Wind / Geomagnetic Activity: The solar wind, as observed by DSCOVR at L1, generally followed a slow regime, with variation between 300 and 325km/s in the solar wind speed itself. The solar wind density started slightly elevated: narrowly in double-figures ppcc, but generally fell with time back into single figures. The IMF also showed a decaying envelope from a slightly elevated start point of 10nT, falling to more typical background behaviour as time went on. The north-south component was mainly co-aligned with Earth's field at first, peaking at +9nT, but falling and becoming more variable, with a maximum southward deflection of -6nT observed.

The cause of the aforementioned slightly elevated solar wind parameters may be related to the tail end of a possible close pass of either CH66/-, or perhaps the overdue 16 March CME, although the effect on geomagnetism was nevertheless very muted. Provisionally, the peak Kp index seen in the past 24 hours was an Unsettled 3- in the 21-24UTC interval, else being Quiet.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) measured at GOES 16 showed an enhancement in the period, with this likely to be related to the far-sided southwestern limb event spawning the the Type-II radio burst. At the time of writing, the 10MeV proton flux has peaked short of S1 at near 6pfu (S1 being 10pfu), while the 100MeV trace appears to have plateaued, having reached 1 particle every two seconds (short of the required particle per second for any alert/warning).

The high energy electron flux (greater than 2 MeV) has been at generally Normal Background levels, and the 24-hour integrated electron fluence was consequently well below the Active (1e8 integrated pfu) threshold, with a slight declining trend. Observed fluence at 21/0000UTC was 1.22e6 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is forecast to continue Very Low or Low, perhaps with a slightly

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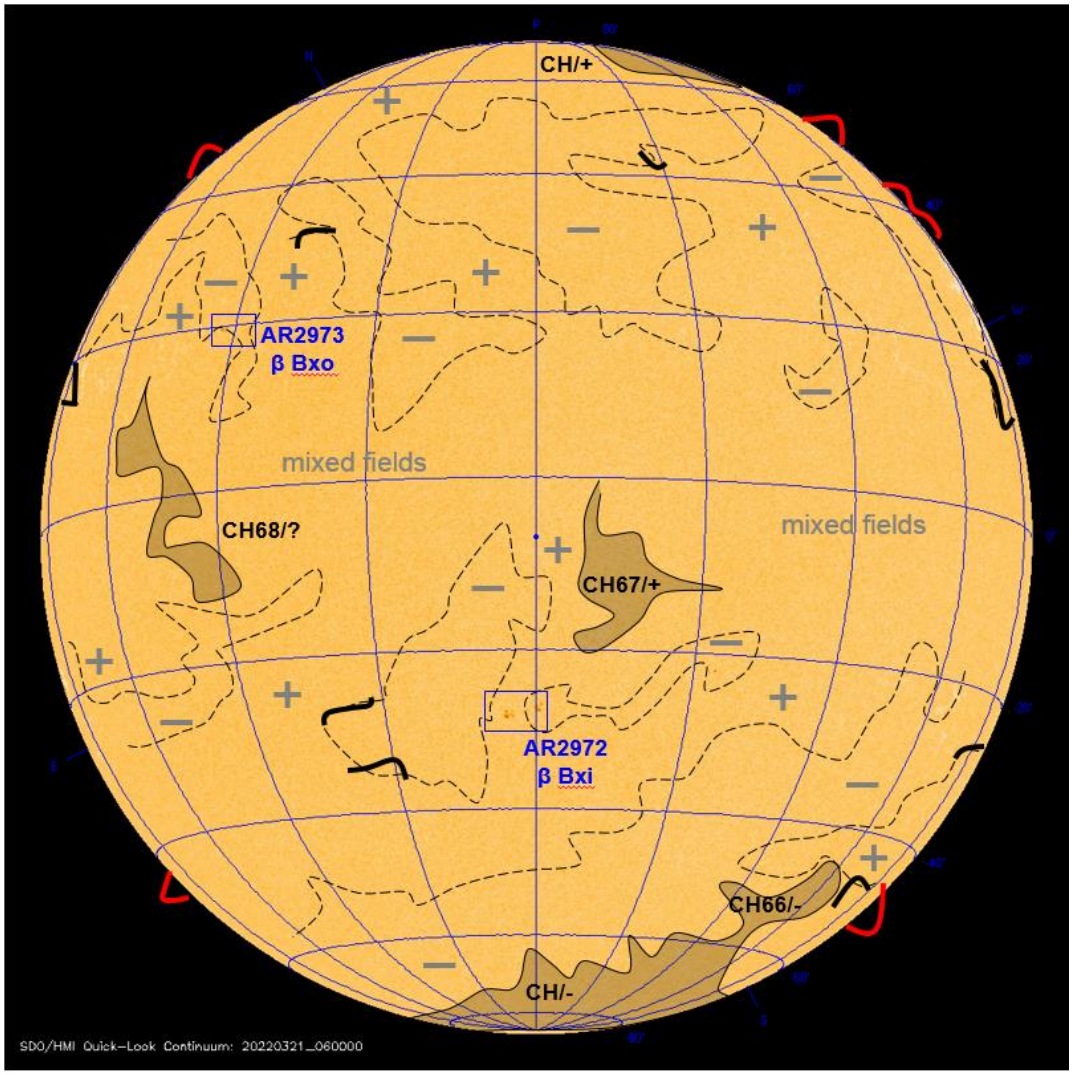
increasing risk with time as a result of possible active regions nearing the eastern limb.

Solar Wind / Geomagnetic Activity: There is one CME (emitted 20/0745UTC) and one coronal hole (CH67/+) in the current forecast. Both are due within day four (Thursday 24 March), both small in their own right but potentially combining to give a 10% risk of G1 at the very end of the period. Solar winds should otherwise be mainly Quiet.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to revert to Background levels after the current enhancement. This has most likely peaked short of 10MeV/100MeV alert thresholds but will be monitored.

The high energy (greater than 2 MeV) electron flux is currently at Normal Background levels, and there is not thought to be any mechanism for its increase due until the very end of the four-day period (the glancing CME and CH67). Active 24-hour integrated fluence (1e8 integrated pfu) is not expected in the forecast period.

Figure 1. Solar Analysis Valid 21/0600UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

Solar winds over the past UTC weekend showed a slight enhancement in some measures (IMF, density) that may hint at peripheral influence of a CIR from CH66/-, or a passing shock from the 16 March CME. Whatever the cause, the resultant effect on geomagnetism was muted, and both are now dropped from the forecast.

In terms of other CMEs, there is one other in the forecast: that tied to the 20/0745UTC C4.6 X-ray flare from the plage remnant of Ex-2971 in northeast quadrant. This has been assessed in MOSWOC Enlil as bearing a possible glancing Earth-directed component, with this due 24/2300UTC. No other CMEs feature in the forecast.

There is otherwise just one non-persistent coronal hole due in the forecast period - CH67 that currently lies near centre disc. This is both small and of positive polarity, and effects are likely to be muted as a result, probably limited to Active within day four, Thursday 24 March, but perhaps giving an overall risk of 10% for G1 when taken with any concurrent CIR leading CH67. Current MAG and PLASTIC data from STEREO A appears to be polluted by a passing transient, but up until this occurred, there were no signs of CH67 affecting the satellite, putting any arrival at Earth beyond the immediate 48 hours.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	1	1	1	10
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
20/03/2022 22:40	Partial	Plage from Ex-2971	N09 E020	210km/s	24/2300UTC	Slow CME directed towards NE following C4 flare. Most ejecta appears directed N and E of the Sun-earth line

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Figure 2: Past 3 days in L1 solar wind measures, showing possible CME or CIR-related enhancement through the UTC weekend, mainly visible in terms of density and IMF/Bz. This did not result in signficant geomagnetic activity, but is part of the rationale for dropping any further mention of CH66/- and the 16 March CME.

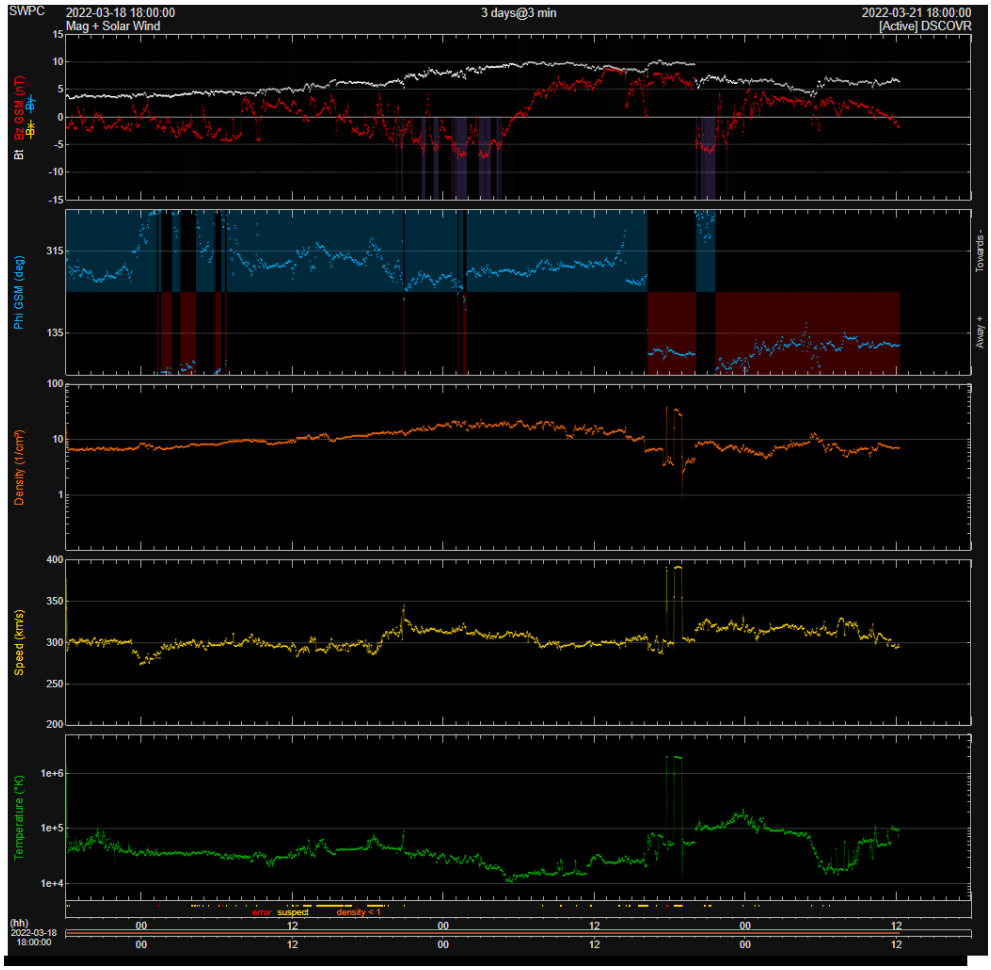
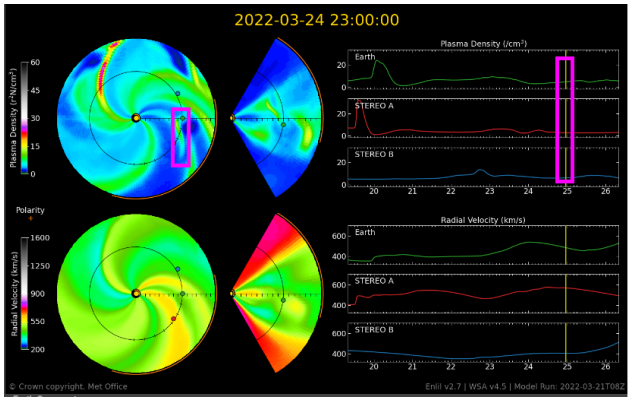
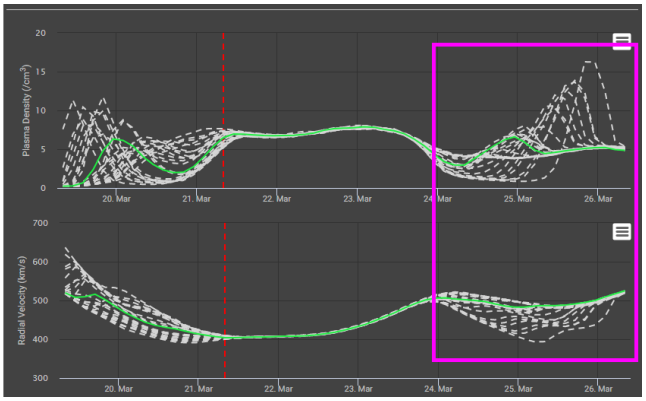


Figure 3: Latest MOSWOC Enlil run and ensemble, showing potential glancing incidence of 20 March CME late on 24 March. Also shown as residual perturbations in the ensemble is the tail of forecast 16 March CME in the immediate term – this may have bypassed Earth over the past UTC weekend.





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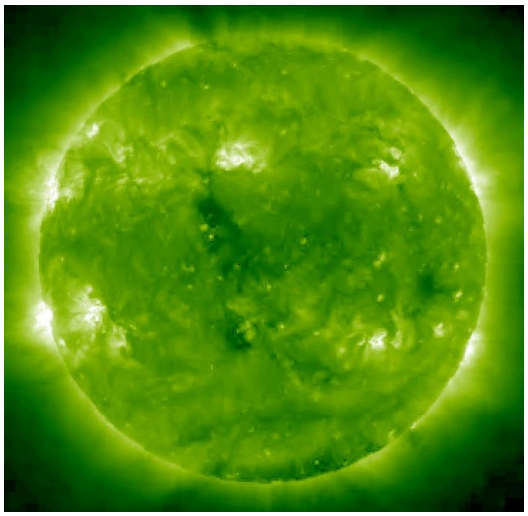
Radio Blackouts - X-Ray Flares:

Solar activity has been Low over the past 24 hours, and the current crop of visible front sided sunspots is unlikely to yield significant activity, being stable Zurich B-groups. Attention therefore turns to a visibly more active eastern solar horizon, with the peak flare of the past 24 hours appearing to emanate from a new region in the southeast, although limb foreshortening is preventing analysis of any culprit. This may be added to after midweek UTC by a further northern hemisphere group.

Significant X-ray flares are therefore not expected in the period, although the likely trend in activity is upwards. The degree to which this may manifest will be assessed when any eastern limb sunspots become visible from Earth.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	1	1	1	1
Very Active	R3 to R5 X Class	No	1	1	1	1

Figure 4: STEREO A EUVI 195 image, showing upcoming possible trio of sunspot regions over the eastern solar horizon when viewed from Earth.



Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (10MeV) measured at GOES-16 showed a slight enhancement in the past 24 hours, although the source for this event is unclear for being far-sided in origin. This presents some difficulty in forecasting repeats of such events, as it is not clear whether the flare/CME was generated by an active region or a filament, although given its apparently relatively solar pole-ward source, the latter is perhaps the more attractive hypothesis.

There is a slightly raised risk of the current flux continuing up to the S1 threshold in the coming

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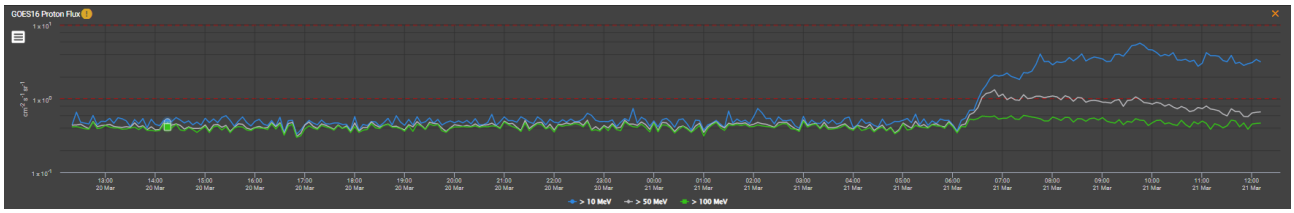
few hours, but should this not occur, repeats of this event are considered unlikely in the four-day period, and the risk therefore soon reverts to background.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	5	1	1	1
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 5: Past 24 hours in GOES 16 high energy proton fluxes, with the enhancement tied to the far-sided CME clearly visible starting just after 21/0600UTC. All energy levels appear to have plateaued, with the ensuing hours determining whether this sustained or not.



High Energy Electrons Event (≥ 2MeV):

The high energy (greater than 2 MeV) electron flux as observed at GEO by GOES-16 is currently at Normal Background levels, with any significant enhancement in the near term unlikely. The next potential enhancement may come from CH67/+ on day 4 (24 March), but this is also unlikely to raise electron levels enough to reach the Active fluence threshold in the forecast period. The general trend on MOSWOC REFM is currently flat and well below Active, with this accepted.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	1	1	10
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

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